

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 045 623 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

18.10.2000 Bulletin 2000/42

(51) Int. Cl.⁷: H05B 41/392, H05B 41/18

(21) Application number: 00302926.1

(22) Date of filing: 06.04.2000

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: 13.04.1999 IL 12940599

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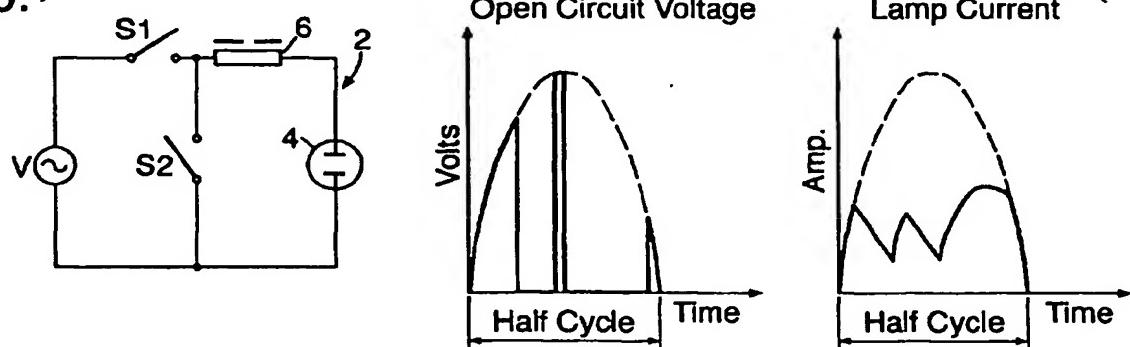
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(54) A dimmer and dimming lighting system

(57) The invention provides a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, the system including at least one switching component operable to connect the mains voltage to the lamp's circuit at certain periods of time and to provide a short circuit

across the lamp's circuit between the periods of time, and a control circuit for sensing the mains voltage and selectively activating the switching component with reference to the mains voltage.

Fig.5.



Description**Field of the Invention**

[0001] The present invention relates to a dimmer and dimming lighting system that include discharge lamps and ballasts. In particular, the present invention is concerned with a dimmer and dimmable lighting systems consisting of magnetic ballasts and operated with low frequency mains voltage.

Background of the Invention

[0002] The current lighting technology utilizes dimmable systems as follows:

[0003] Dimming is performed by means of an additional ballast connected in series with the main ballast (Fig. 1). Thereby, the original open circuit voltage is maintained in any dimming state, while the lamp current is reduced but remains sinusoidal. The main disadvantage of this method is that an additional ballast must be added in series to each lamp in order to achieve dimming. Another disadvantage is that the reduced lamp current has a reduced slope near its zero crossing. Thereby, the re-ignition of the lamp at the beginning of each new half-current cycle becomes more difficult as the dimming becomes deeper.

[0004] Another method of dimming is performed by lowering the input voltage to the lighting system (Fig. 2). As compared to the above-described method, this method can be applied to a group of lamps using a single dimming device, but it has the disadvantage that the lower open circuit voltage in the dimming mode soon becomes insufficient for a new half cycle re-ignition. Hence, a dimming of only about 25% is possible with this method.

[0005] Still another method of dimming is performed by increasing the ballast current frequency (Fig. 3). This method has the disadvantage of increased ballast watt loss, with increased frequency and increased ballast noise, which, with magnetic ballasts, actually becomes intolerable.

[0006] A further method of dimming is performed by means of a phase-controlled electronic switch that disconnects the mains voltage during some parts of the voltage cycle (Fig. 4). The disadvantage of this method is the lamp current interruptions created by the switch. With deeper dimming, these interruptions become longer, which very soon makes new half-cycle re-ignition impossible unless the lamp cathodes are continuously heated by special means.

Summary of the Invention

[0007] It is therefore a broad object of the present invention to ameliorate the disadvantages of the prior art dimming systems and to provide a dimmer and a dimming system in which a deep dimming level is

obtainable without lamp cathode heating.

[0008] In accordance with the present invention, there is thus provided a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said system comprising at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

[0009] The invention further provides a dimmer for a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said dimmer comprising at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

[0010] In general, the present invention combines the advantages of high open circuit voltage with the advantages of continuous lamp current having steep slope at zero crossing, together with the advantages of handling many lamps by means of a single switching component. More specifically, the advantages of high open circuit voltage constitute stable lamp operation and safe half-cycle re-ignition, while the advantages of continuous lamp current having steep slope at zero crossing induce even more stable operation and reduction of the required re-ignition voltages. The advantage of handling many lamps operated with magnetic ballasts by means of single switch is simplicity and low cost as well as the option to use the invention with existing lighting systems.

Brief Description of the Drawings

[0011] The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

[0012] With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in prac-

tice.

[0013] In the drawings:

Figs. 1 to 4 are circuit diagrams and characteristic curves of prior art dimmers;

Fig. 5 is a circuit diagram and characteristic curves of a preferred embodiment of the present invention; Fig. 6 is a block and circuit diagram of a dimming arrangement for a plurality of lamps utilizing the dimmer according to the present invention;

Fig. 7 is a block diagram of the dimming system according to the present invention;

Fig. 8 is a circuit diagram of an embodiment of a dimming system according to Fig. 7, and

Fig. 9 is a further embodiment of a dimming arrangement, and

Fig. 10 is a circuit diagram of an embodiment of the switch of Fig. 9.

Detailed Description of Preferred Embodiments

[0014] In contradistinction to the above-described prior art dimmers, in Fig. 5 there is illustrated a dimmer 2 powered from a mains and connectable across a discharge or fluorescent lamp 4. The dimmer consists of two switches S_1 and S_2 , e.g., solid state switches, and a ballast 6. S_1 is connected between the mains and the lamp's circuit components 4 and 6; S_2 is connected in parallel to the lamp's circuit components 4 and 6. Switches S_1 and S_2 operate in such a manner that when S_1 is open, S_2 is closed, and vice-versa. Thus, the lamp's current continues to flow, due to energy stored in the magnetic ballast 6, as seen in the characteristic curves. The high open circuit voltage and steep lamp current at zero crossing facilitate deep dimming without special cathode heating.

[0015] The dimmer according to the present invention can be utilized as a central dimmer for a plurality of discharge lamps, as illustrated in Fig. 6. The central dimmer 2 is advantageously connected across the mains via a power factor correction capacitor 8. The discharge lamps 4, in this case, compact fluorescent lamps (CFL), are connected to the mains lines 10 via suitable *per se* known adaptors 12, each including a magnetic ballast (not shown), as opposed to the ballast 6 shown in Fig. 5, which constitutes a separate component.

[0016] The dimmer of the dimmable lighting system according to the present invention is illustrated in Figs. 7 and 8. Fig. 8 merely represents a preferred embodiment. The mains feeds a power supply 14, composed of two transformers T_2 and T_3 , leading to two bridges D_1 and D_2 and, via capacitors C_3 and C_4 , to the rest of the circuit for supplying the required low DC voltages to the dimmer. The mains also directly feeds a phase detector 16, an optional zero crossing detector and a switching component 18. The mains phase detector includes a transformer T_1 leading through resistors R_1 - R_6 to comparators U1A and U1B and from there to a logic circuit

20, which governs the operation of the switching components 18 in accordance with the setting of the dimming control 22, optionally including a display. The logic circuit consists of two monostable units U3A and U3B and two capacitors C_1 and C_2 leading, via resistors R_9 - R_{11} , to comparators U2A and U2B.

[0017] According to this embodiment, switching component 18 comprises comparators U4A and U5A, and transistors Q_1 - Q_6 , respectively leading to bridges D_3 and D_4 . The logic circuit leads the switching component through two opto-couplers 24 and 26. The dimming control unit 22 is here embodied by the adjustable resistors R_7 and R_8 .

[0018] Hence, as can be understood, the phase detector 16 monitors the mains and identifies its phase, e.g., zero crossings, and transfers this information to the logic circuit 20. Substantially upon the mains voltage crossing the zero line, the logic circuit activates the switching component, at least twice during each half-cycle of the mains voltage, for a duration of time preset by the dimming control, as illustrated in Fig. 5.

[0019] The switching component thus facilitates continuous lamp current at the dimming state while maintaining the original open circuit voltage and nearly the original current slope at zero crossing. This facilitates very effective dimming without special cathode heating, although cathode heating could just as well be applied.

[0020] Fig. 9 illustrates another embodiment of a dimmable lighting system according to the present invention, suitable for assuring efficient re-ignition of a discharge lamp. Seen is a discharge lamp 4, with an igniter 28 connected theracross and a ballast 6 connected to a four-position switch 30. Contacts S_3 and S_6 lead via diodes 32, 34 to one line of the mains, while contact S_4 leads directly to the same line and contact S_5 leads directly to the other line of the mains. In addition, contacts S_3 and S_6 are respectively connected via capacitors 36, 38 to said other line of the mains. Thus, during the periods of time that switch 30 does not directly contact the mains, it contacts alternative voltage sources.

[0021] The operation of the dimmer is as follows: At each cycle of the mains, capacitors 36, 38 are charged to the main's peak voltage. At the termination of the positive half cycle of the mains voltage, the current in lamp 4 will rapidly decrease. In order to slow down the rate of decrease of the current, namely, to delay as far as possible its reaching zero, so as to increase the phase difference between the current and voltage with a view towards improving the lamp's re-ignition, the contact S_3 of switch 30 is closed for a short period or periods of time, thereby causing further current to flow through the lamp. The voltage on the capacitor 36 will decrease until the next positive cycle, in which it will recharge again through diode 32. The operation of the circuit during the negative half-cycle will be the same in conjunction with contact S_6 of switch 30 and capacitor

38. The application of the additional current to the lamp at the proper timing can be easily controlled on the basis of constant measurement of the zero crossing of the mains voltage waves, e.g., in synchronization with phase detector 16 (Figs. 7 and 8).

[0022] A solid-state-based embodiment of the four-position switch 30 of Fig. 9 is shown in Fig. 10. The switch includes four transistors Q₁ to Q₄ for driving current respectively through insulating transformers T₁, T₂, T₈ and T₉. Transistor Q₅ and diode D₆ constitute an OR gate for operating transistor Q₄, and capacitors C₁ and C₂ serve as filters. Diodes D₁ to D₄ facilitate flow of current after cut-off of current to the transformers T₁, T₂, T₈ and T₉. The latter provide operating voltages to the gates of transistors Q₁₄ to Q₁₉, while transistors Q₆ to Q₉ serve as the non-conducting arrangement for transistors Q₁₄ to Q₁₉ by calibrating the gates thereof. Diodes D₅, D₂₃, D₂₈ and D₂₄ enable charging the gates of transistors Q₁₄ to Q₁₉, and diodes D₁₆, D₁₇, D₁₈, D₃₀, D₃₁, D₂₇ and D₂₈ are used as OR gates for operating the non-conducting state of transistors Q₁₄ to Q₁₉. Zener diodes D₁₉, D₂₀, D₂₁ and D₂₂ protect the gates of transistors Q₁₄ to Q₁₉ against high voltage, while resistors R₁ to R₄, R₁₁, R₁₃, R₁₅ and R₁₇ limit the current flow to these transistors. Resistors R₅, R₁₀, R₁₂, R₁₄ and R₁₆ are discharge passageways from the bases of the transistors Q₄, Q₆ to Q₉. Capacitors C₃, C₄ and C₆ retain the charge on the gates of transistors Q₁₆ to Q₁₉.

[0023] The operation of the switch 30 is as follows: a voltage pulse applied to input "MAIN ON" activates transistor Q₃, causing current to flow through the primary of transformer T₈. The resulting voltage across points 3, 4 of the secondary coil of the transformer charges transistors Q₁₄ and Q₁₅ through diode D₂₃, rendering the transistors conductive. Simultaneously, the voltages built up across points 5, 6; 7, 8 and 9, 10 of the secondary coils of transformer T₈ render transistors Q₆, Q₇ and Q₉ conductive, causing discharge of the gates of transistors Q₁₈, Q₁₉, Q₁₆ and Q₁₇, respectively, thus preventing the flow of current therethrough. A similar operation takes place upon the appearance of a voltage pulse across inputs "BOOST+", "BOOST-" and "FREE WHEEL."

[0024] It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

Claims

- 5 1. A dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said system comprising:

at least one switching component operable to connect the mains voltage to the lamp's circuit at certain periods of time and to provide a short circuit across said lamp's circuit between said periods of time, and
a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

- 10 2. The dimmable lighting system as claimed in claim 1, wherein said switching component consists of a changeover solid state switch.

- 20 3. The dimmable lighting system as claimed in claim 2, wherein said changeover solid state switch consists of a first on-off AC switch connected between said mains and said lamp circuit and a second on-off AC switch connected in parallel to said lamp circuit.

- 25 4. The dimmable lighting system as claimed in claim 1, wherein said ballast is a coil-core magnetic ballast.

- 30 5. The dimmable lighting system as claimed in claim 1, wherein said control circuit senses zero crossing of the mains voltage and changes the state of said switching component at least twice during each half cycle of said mains voltage.

- 35 6. The dimmable lighting system as claimed in claim 1, wherein said control circuit comprises means for adjusting the level of light intensity.

- 40 7. The dimmable lighting system as claimed in claim 1, wherein said control circuit comprises a sensor for identifying mains voltage zero-crossing and for activating timing means for actuating said switching component at certain time intervals following the zero crossing.

- 45 8. A dimmer for a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said dimmer comprising:

55 at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and
a control circuit for sensing the mains voltage

and selectively activating said switching component with reference to said mains voltage.

9. The dimmable lighting system as claimed in claim 1, wherein, during periods of time that said switching component does not contact the mains, it contacts alternative voltage sources. 5
10. The dimmable lighting system as claimed in claim 9, wherein said alternative voltage sources are 10 capacitors.

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Fig. 1. (Prior Art)

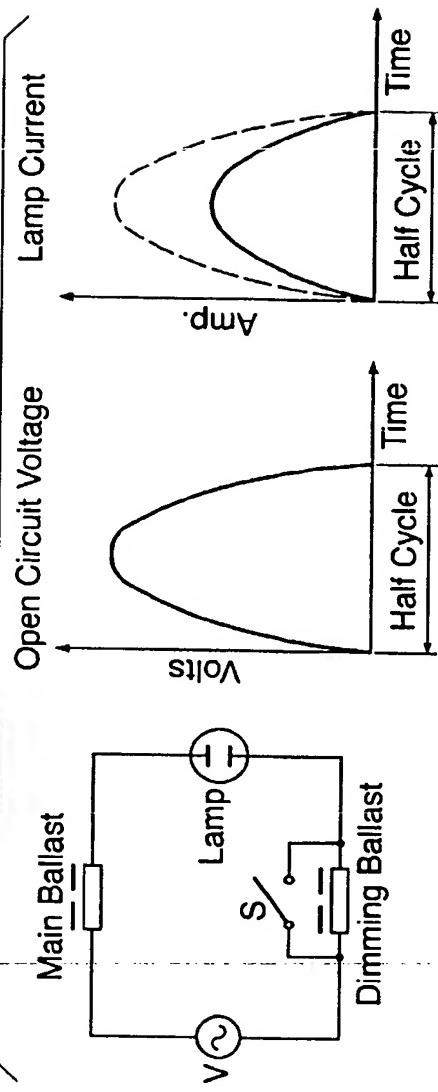


Fig. 2. (Prior Art)

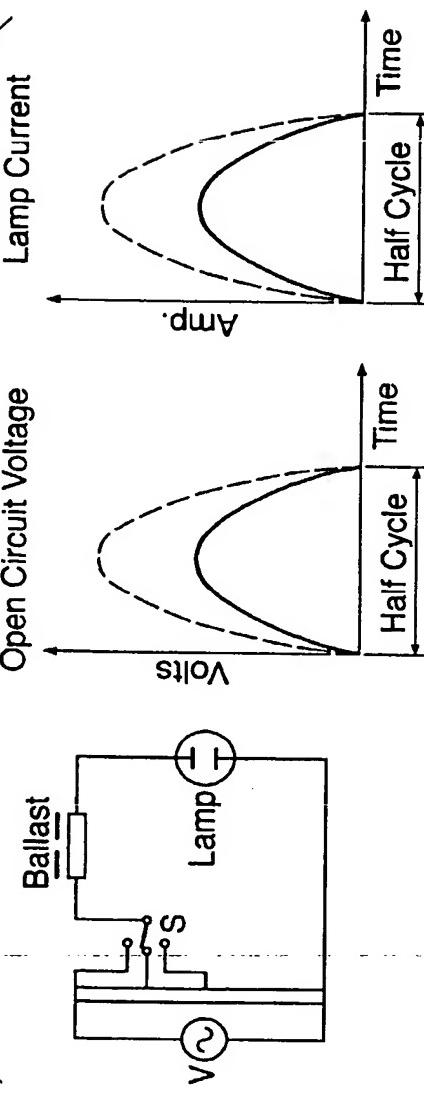
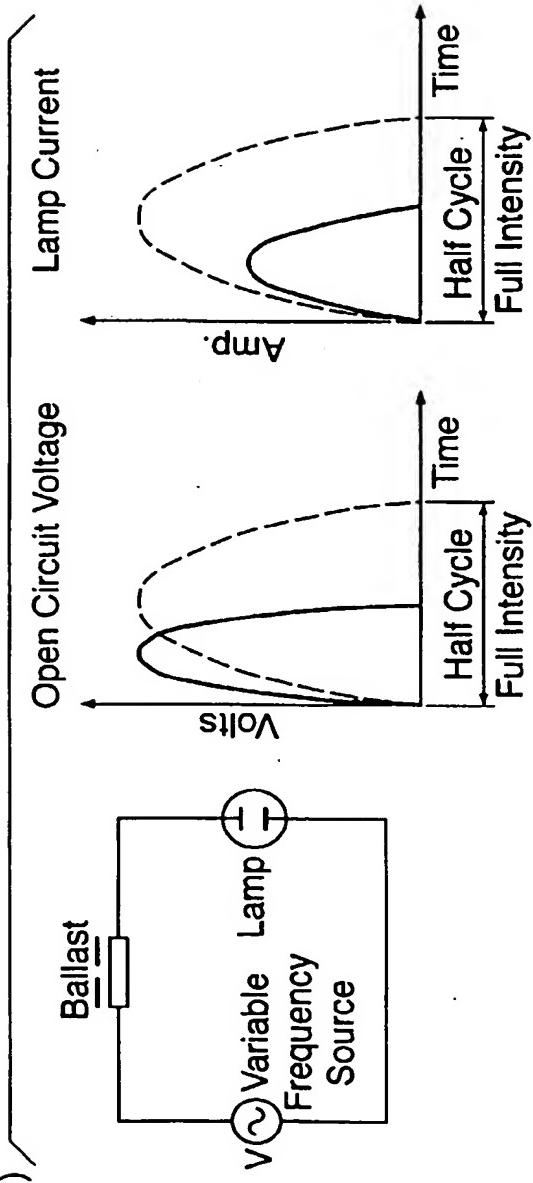
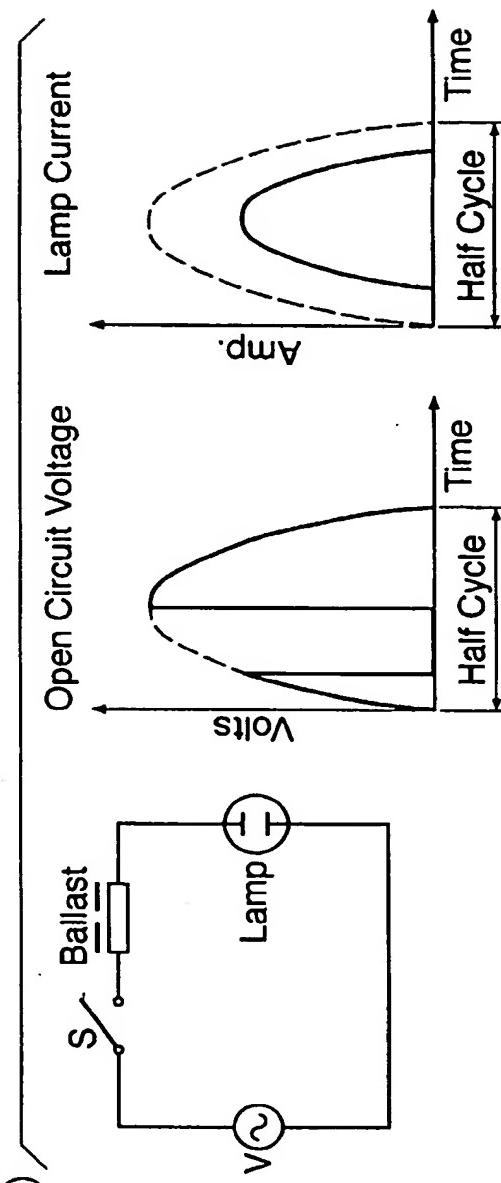


Fig.3. (Prior Art)**Fig.4. (Prior Art)**

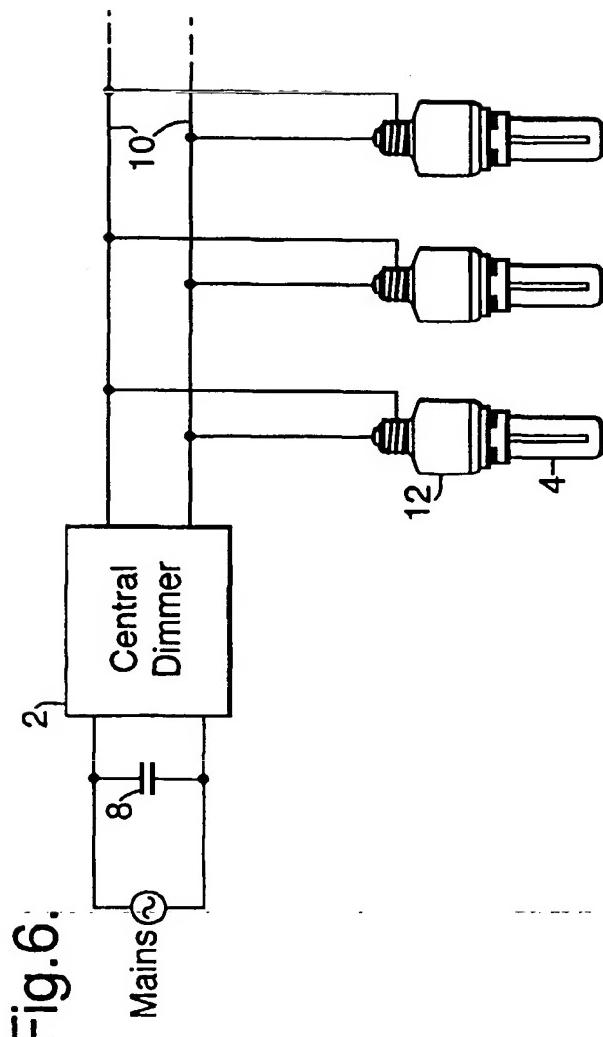
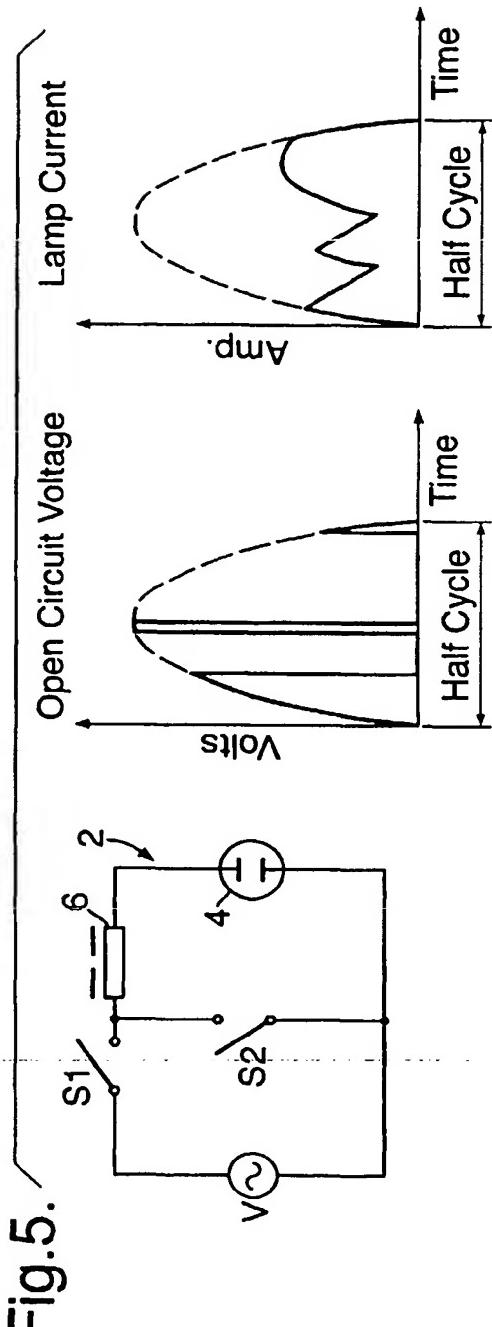


Fig.7.

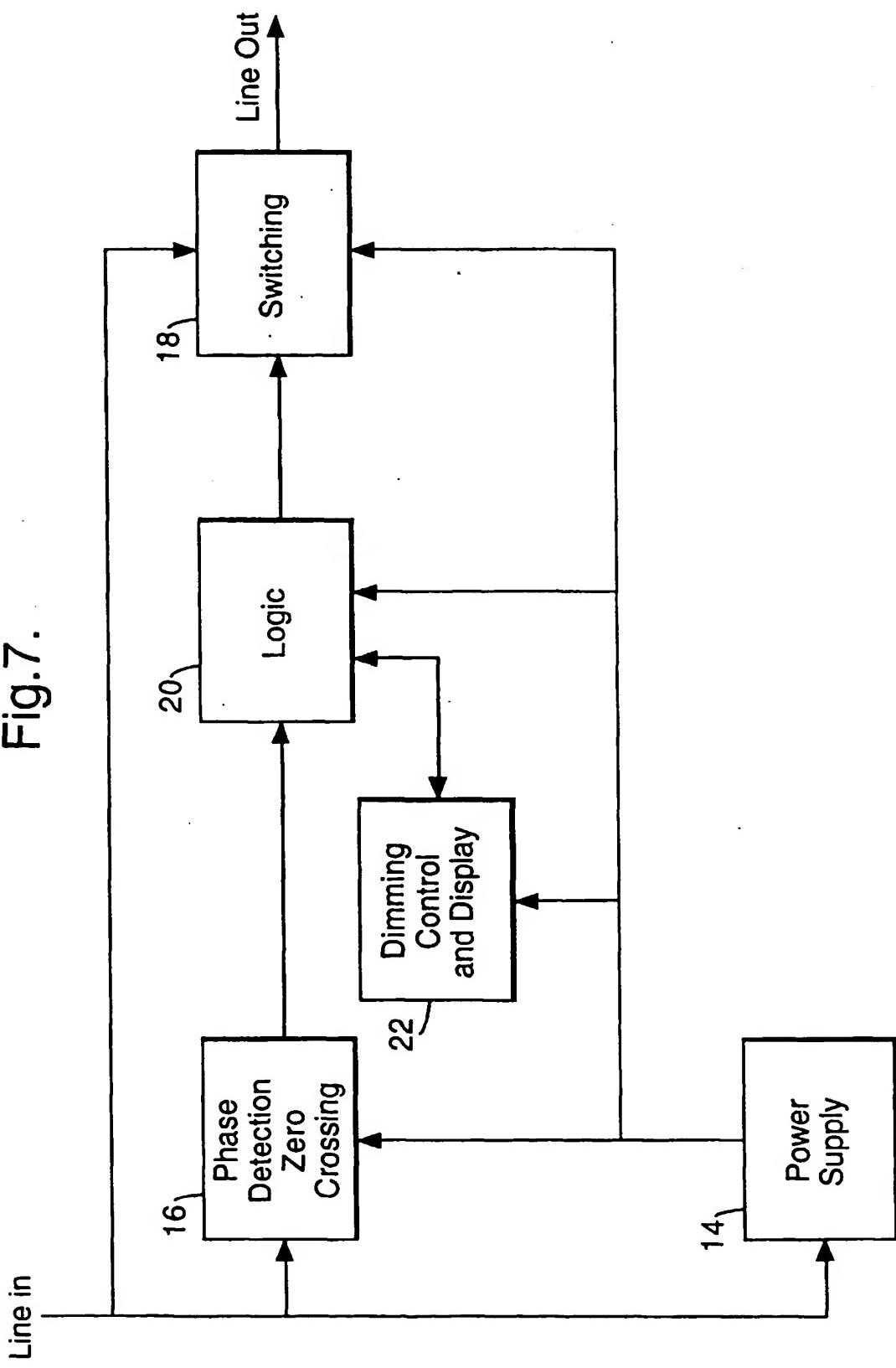


Fig.8.

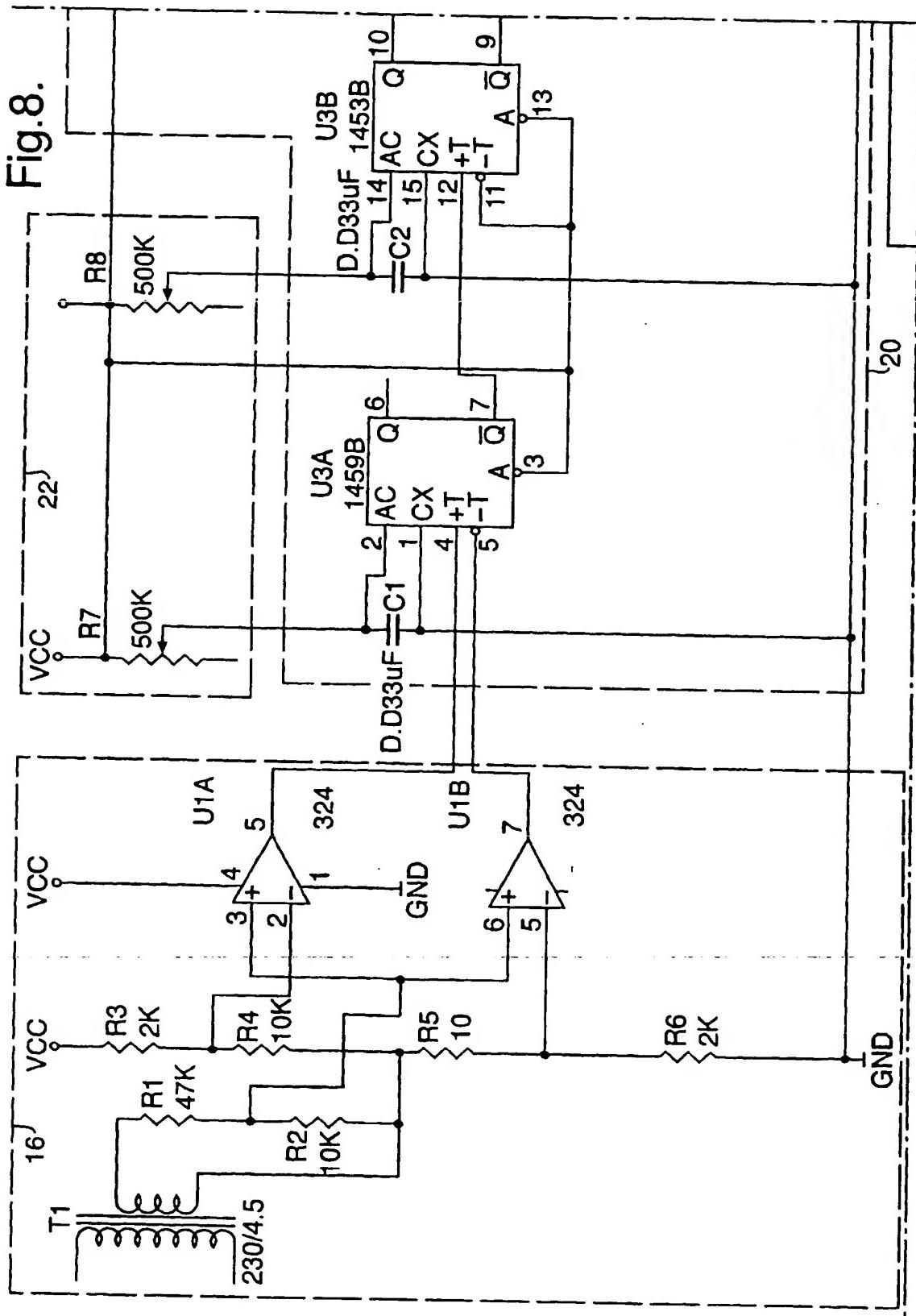


Fig.8 (Cont i).

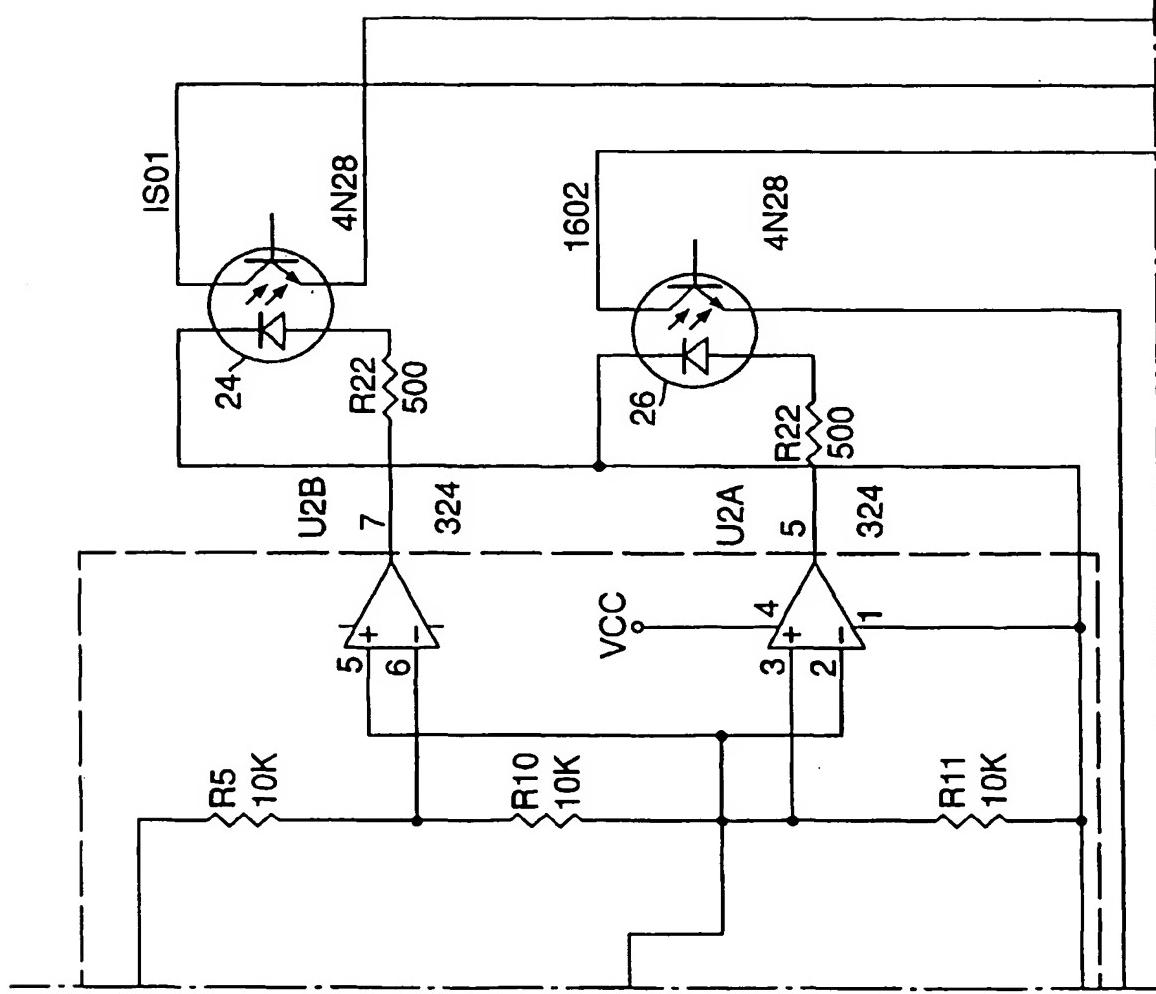
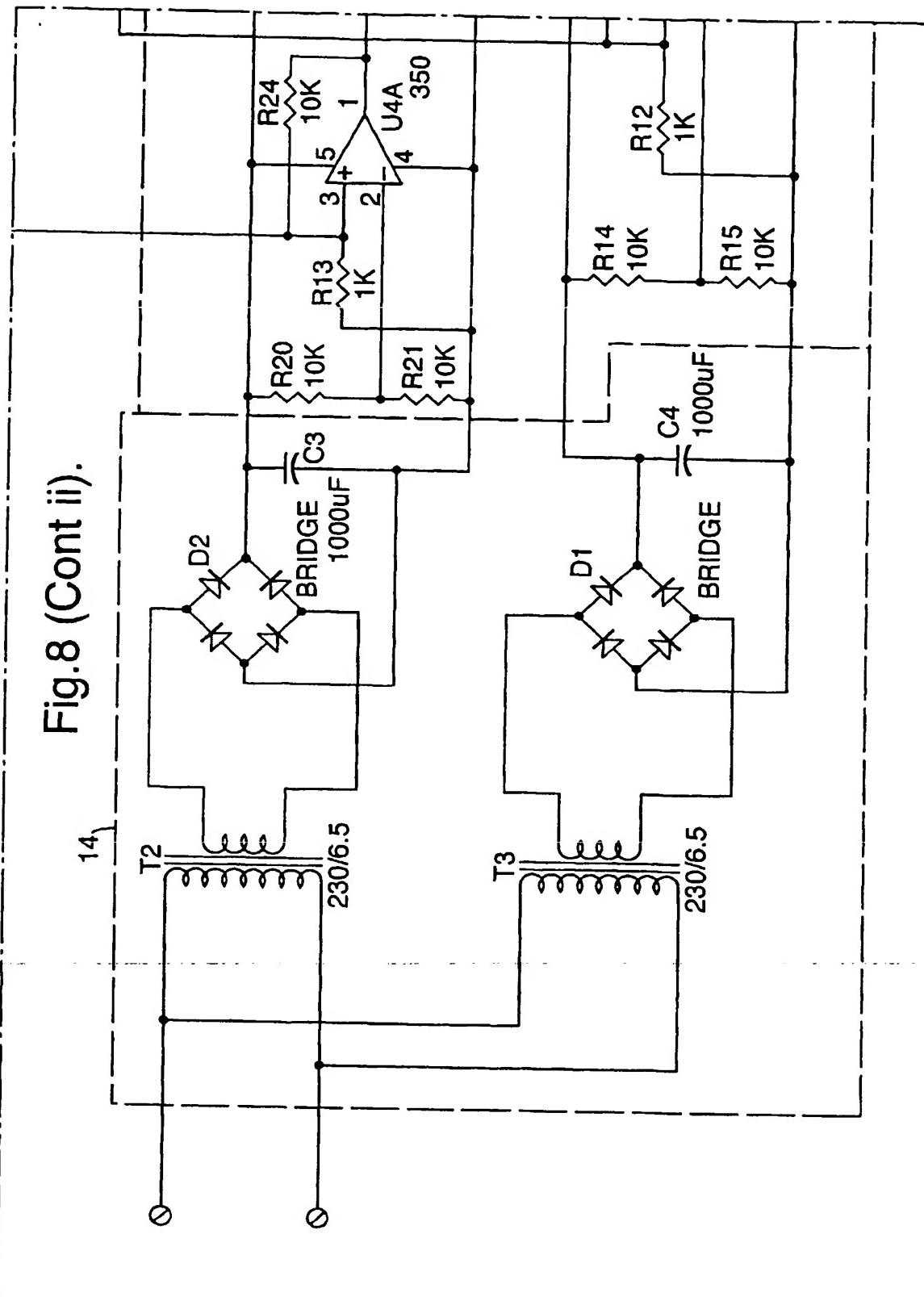


Fig.8 (Cont ii).



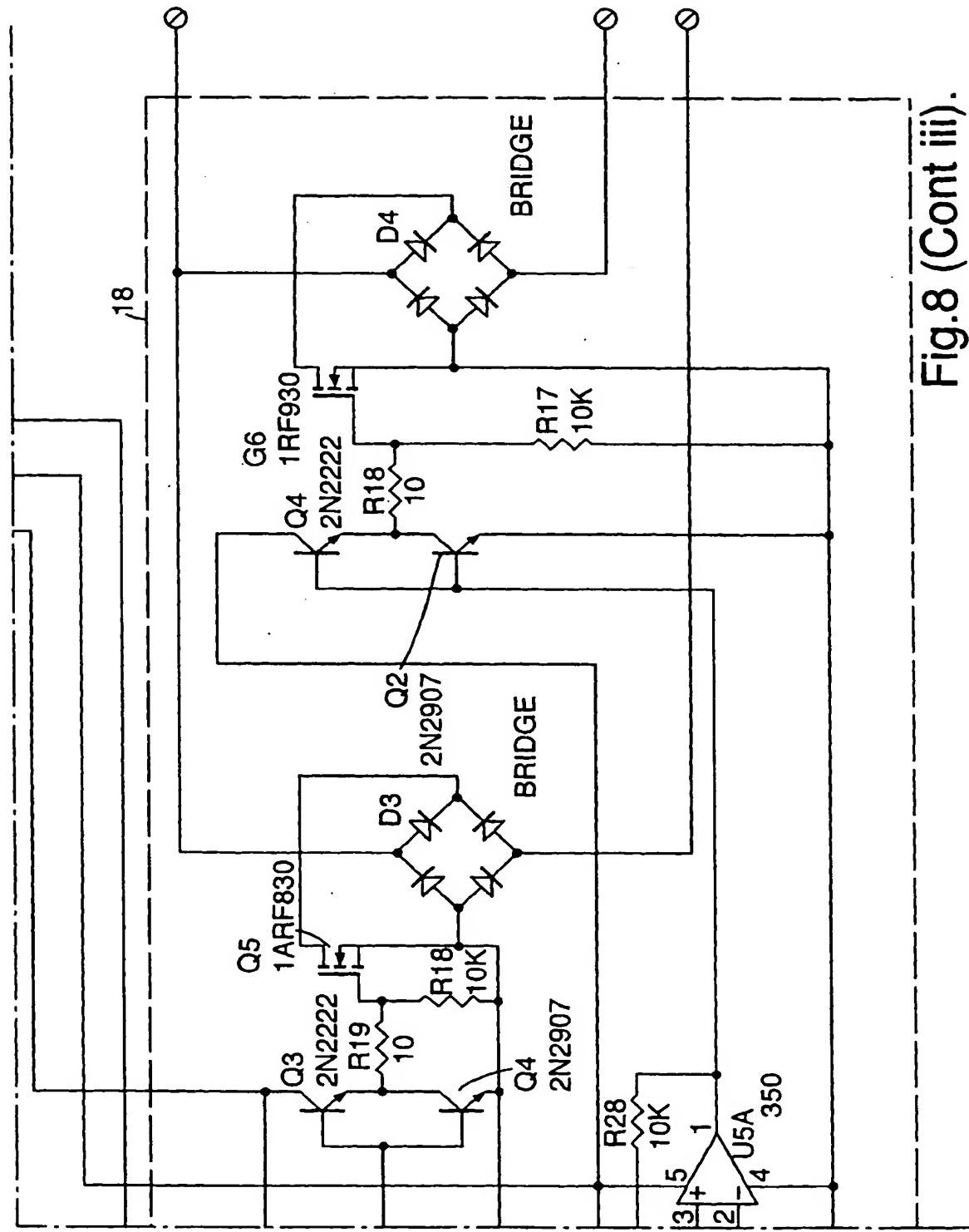


Fig.8 (Cont iii).

Fig.9.

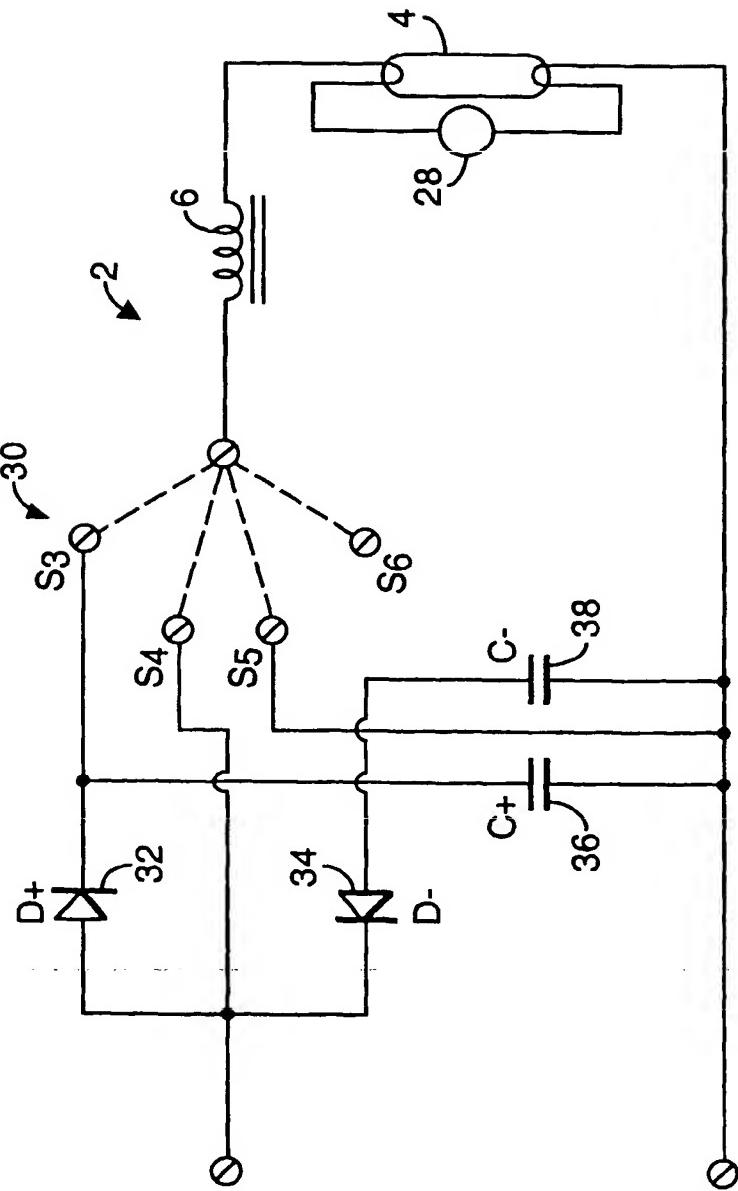


Fig.10.

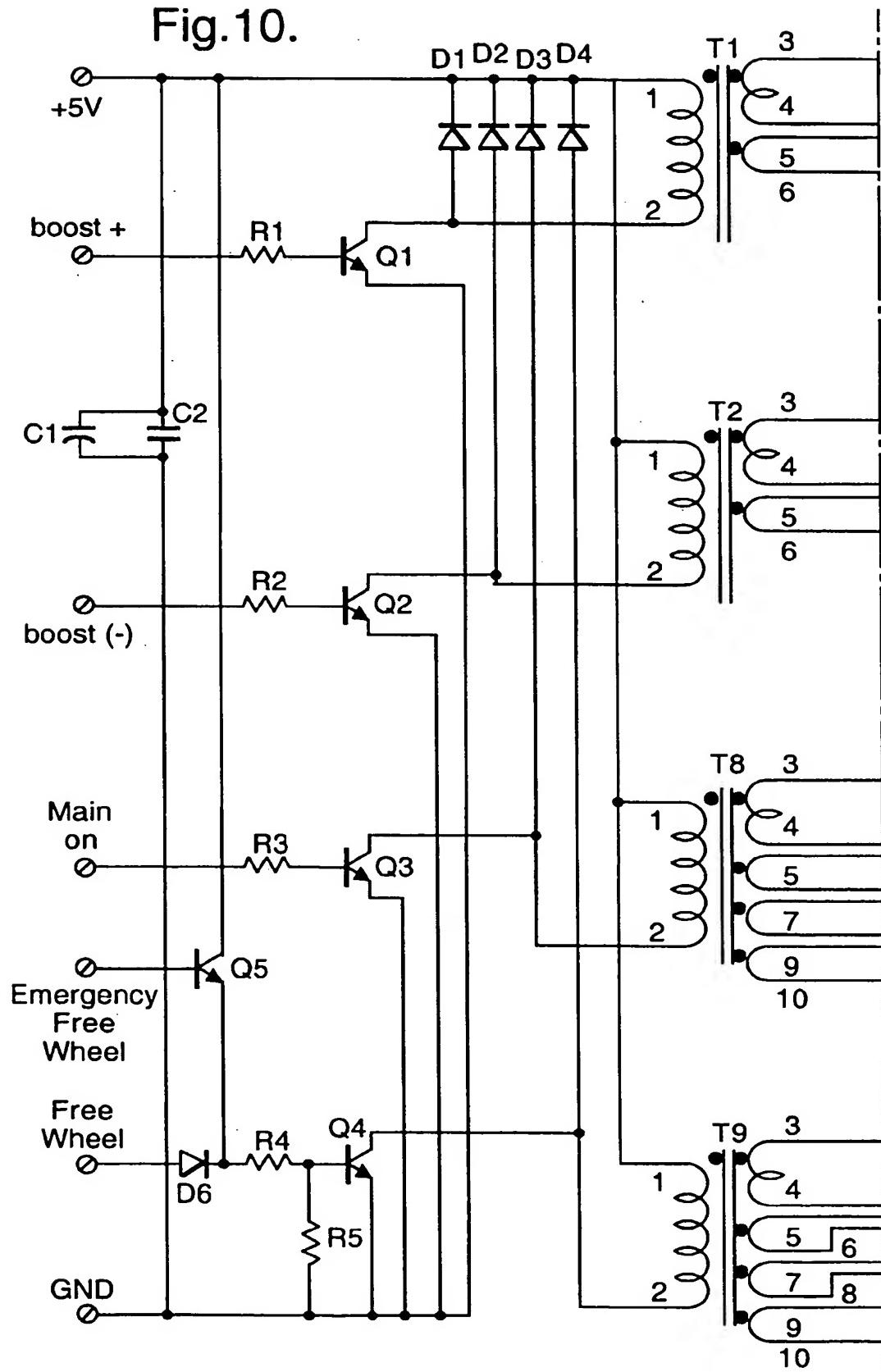


Fig.10 (Cont i).

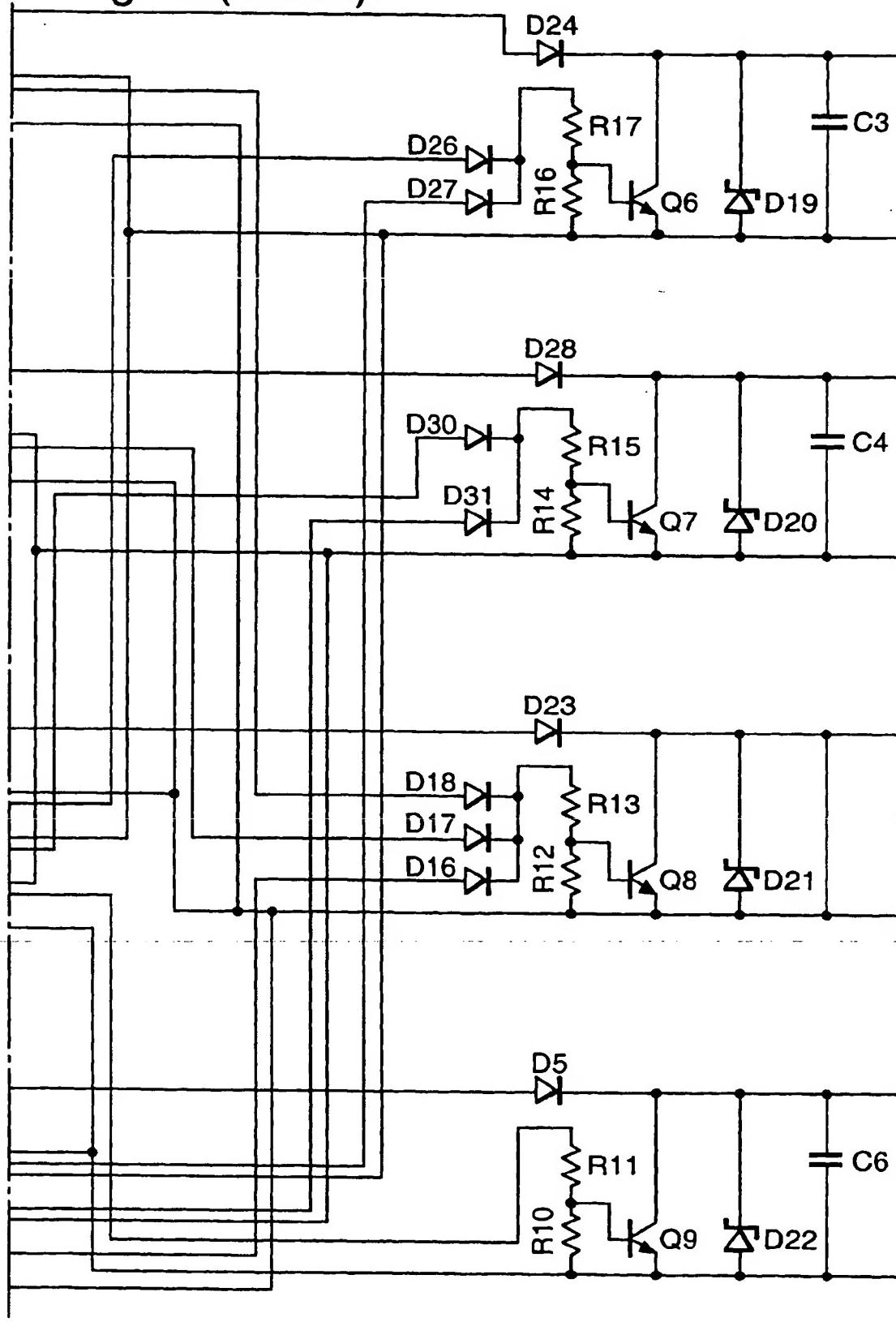
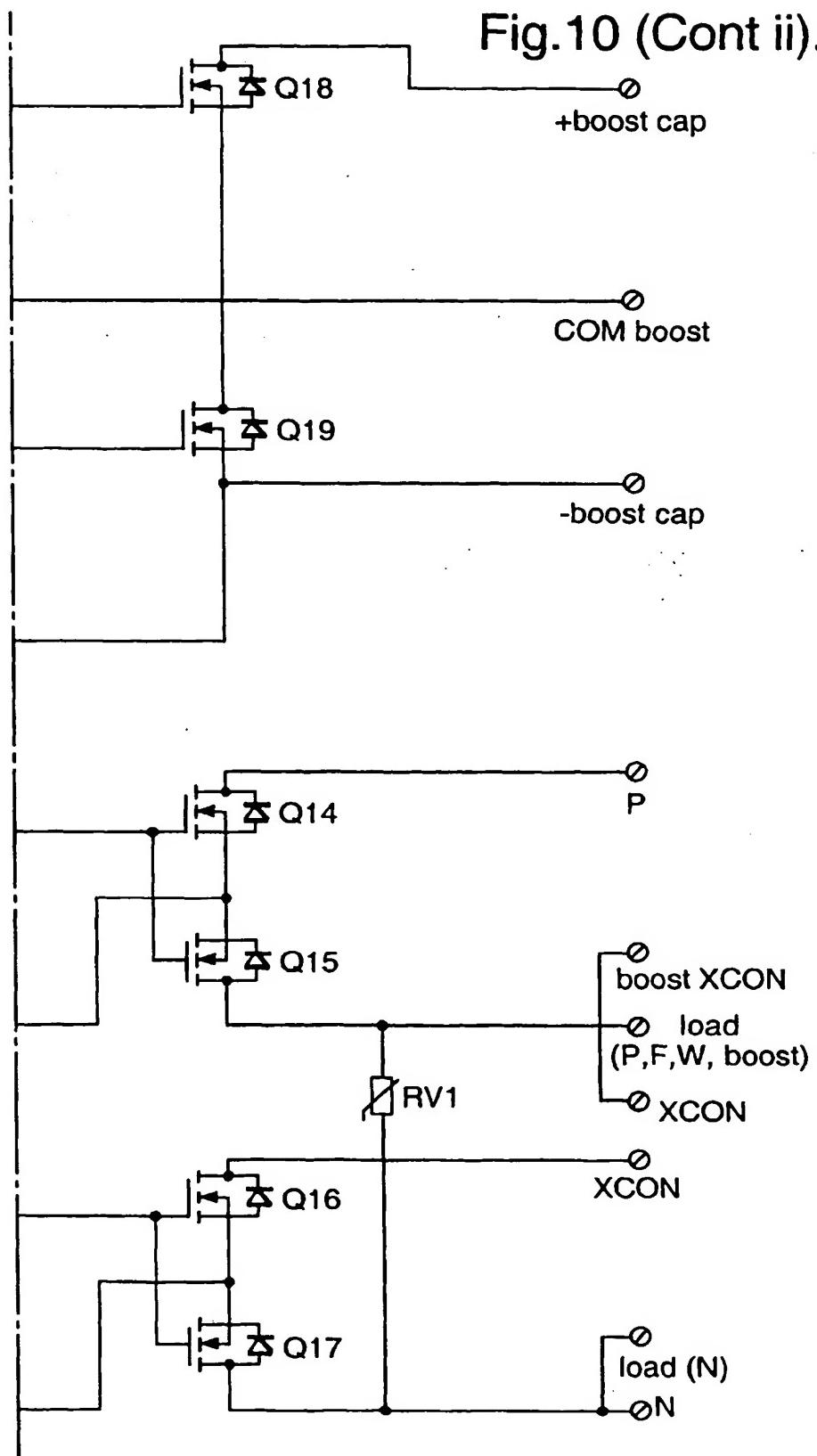


Fig.10 (Cont ii).





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(11)

EP 1 045 623 A3

(12)

EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
06.02.2002 Bulletin 2002/06

(51) Int Cl.7: H05B 41/392, H05B 41/18

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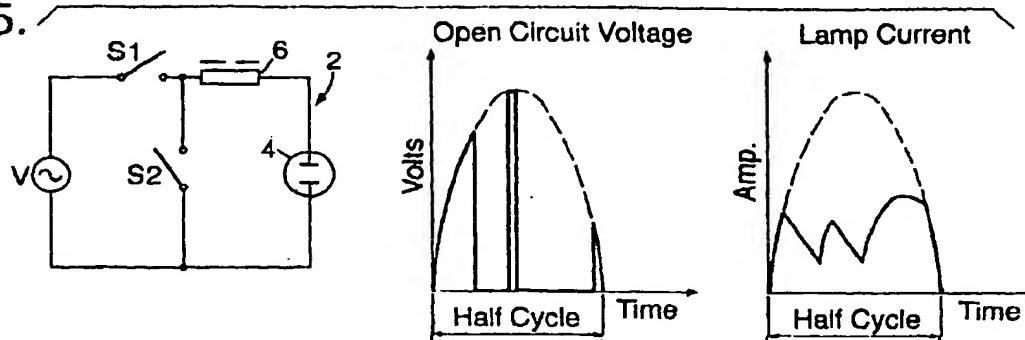
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Fig.5.





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